Detection of Muons using a Digital Optical Module System in the South Pole Ice

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IceCube will be a neutrino detector that can detect high energy galactic neutrinos. It will be located at the South Pole and have an active area of approximately one cubic kilometer. Given the 2.5 km length of the cables and the finality of modules frozen in the ice, the collaboration has decided to replace the conventional analog technology with a new digital design.

LBNL has designed a fully digital technology in which the signal from the photomultiplier tube is digitized in the Digital Optical Module (DOM). All information is sent to surface in digital form. Additional features include an increased dynamic range, waveform digitization at speeds of 500 mega-samples per second, local coincidence timing among adjacent modules, automatic time synchronization and calibration, and remote control of the system.

Forty-one DOMs were deployed at the South Pole in January 2000 as a part of AMANDA. Only three modules failed during deployment or in the first year. These 3 failures apparently originated with the PMT base, and not with the DOM electronic components. As of March 2002, only one additional module has failed.

To detect a muon, we must calibrate the local clocks of the individual modules. We have been commissioning the firmware in the ice and the surface data acquisition system at LBNL. Recent work has demonstrated that we can achieve time calibration to within 1 to 2 ns, which is better than the phototube time resolution.

Using these calibrated modules, we recorded data from two pairs of DOMs that were 200 m apart. Data were recorded when each pair registered an *in ice* hardware coincidence. The top graph of Fig. 1 shows the time difference between the two pairs, while the bottom graph shows the expected data using the Monte Carlo code Corsika for downward going muons. Clearly, the agreement gives compelling evidence that we have detected muons.

At the 2001-2002 summer season at the pole, we replaced the *above ice* DAQ with hardware that can simultaneously record data from all of the operational DOMs. Currently, we are developing software to measure muons with all the DOMs.

Footnotes and References

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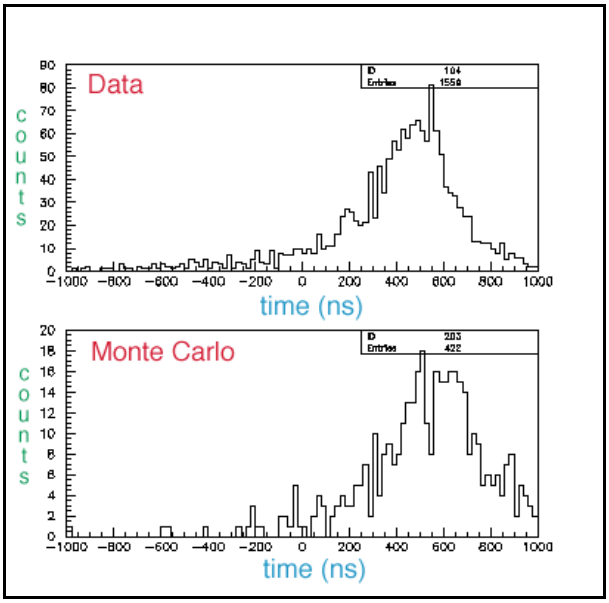

Fig. 1. The upper plot shows the time delay between the upper set of optical modules and the lower set. The lower plot is a Monte Carlo calculation.